



## Exploring Textiles in Architecture through Tangible Three-Dimensional Sketching Tools

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*Publication date:*  
2012

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### *Citation (APA):*

Heimdal, E. J., Lenau, T. A., & O'Mahony, M. (2012). *Exploring Textiles in Architecture through Tangible Three-Dimensional Sketching Tools*. Paper presented at MAKING, Notodden, Norway.

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*Elisabeth Heimdal, Torben Lenau and Marie O'Mahony*

## Exploring Textiles in Architecture through Tangible Three-Dimensional Sketching Tools

### Abstract

*This paper argues that tangible three dimensional sketching with textiles makes it more likely that these materials will be used when creating architectural spaces. Our research contributes to the more general idea that innovation in architecture and design can be stimulated by the exploration of new materials. With tangible three dimensional sketching, we mean an iterative process of physical model making. In two experiments with architectural students, all textile novices, spaces were modelled using a three dimensional sketching tool consisting of textiles, cardboard support and tools for giving form to and joining these materials. The chosen architectural task was how textiles could be used to regulate daylight by applying them to an exterior building skin or to interior spaces. Findings were that three different strategies were used: the tool was used to materialize, illustrate, or develop a concept. While the first two strategies use pre-existing ideas – respectively immaterialized (such as an idea) or materialized (such as an existing building or a sketch) – as point of departure, the third strategy uses the tool to develop new ideas. Our experiments demonstrate that textiles' possibilities can indeed be explored through tangible three-dimensional sketching and that limitations and clear progression in the staging of the tool produce better models and deeper exploration. In order to extend the results to practice, a professional architect was interviewed. Based on this, we can say that the tools, though tested on students, are likely to work for professionals too.*

**Keywords:** textiles, materials, architectural practice, model making, sketching.

### Introduction

Multimodal forms of representations (hand sketches, material samples, physical and digital models) are important in architectural practice (Telier et al., 2011, Wagner, 2004, Yaneva, 2005). However, few look deeper into the role of material samples and materials. Our aim is to understand how architects can make sketches in three dimensions with new materials, in our case, textiles. In this paper, we share our experience from two experiments in which architectural students used tools for model making with textiles. In architecture, possibilities with textiles extend in several directions, including the regulation of sound or daylight, sustainability, room in room and interior walls (Boding-Jensen & Schødt Rasmussen, 2008). Our focus was on the light effects (both functional and aesthetic) that can be created with textiles, whether they are on the inside or the outside of a building. In Experiment 1 (with fourteen architecture students) the context was the redesign of the building skin of the UTS (University of Technology, Sydney) Tower Building; in Experiment 2 (with eleven spatial design students) it was interior spaces in this building.

We see two approaches to materials in creative work: 1) a design approach where materials are seen as solutions, also called the formal approach. In many disciplines (architecture, engineering and some design disciplines), materials are typically treated as solutions – as something that is selected or chosen at some point in the development process (Hensel, 2009), and 2) a formgiving approach where materials are seen as potentials, also called the tectonic approach. This approach is prevalent in craft and in some design disciplines (such as textile design and ceramic design), where it is common to explore a given material by experimenting with different ways of processing and treating it (Lenau, 2002). Looking at

the etymology of the word, Anna Vallgård writes: “Formgiving exists in the Scandinavian languages as *formgivning*, in Dutch as *vormgeving*, and in German as *Gestaltung* and is traditionally used to denote the specific practice of giving form to materials [...]”(Vallgård, 2009) (p. 37). Vallgård explains that formgiving is anchored “in the rich sensory experiences that materials afford.” (p. 43).

Our focus is the use of textiles in architecture, and it therefore makes sense to compare the disciplines of architecture and textile design more closely. As mentioned in the previous paragraph, the formgiving approach is typically used in textile design, while the formal approach is used in architecture. This is because the scale of design is different. In addition to the approach to materials, this difference in scale also affects which kinds of artefacts are used in the design process: scale models are often used in architecture, whereas prototyping is more common in textile design. This can be explained by the fact that textiles are the end-products for textile designers, and at this scale prototyping is easy. For architects, textiles (and other materials) are not the result the design process, but rather the beginning of it. Textiles are thus raw materials for architects. Material samples are used in architecture practice to give a sense of the colour and texture of the environment to be built. Material samples are smaller pieces of the final materials that will be used. These samples are often used to create mood boards showing the palette of materials to be used in a space. In contrast, the materials used in architectural models (typically cardboard or foam) act as stand-ins for other materials (such as concrete).

When a material is used by new stakeholders, as is the case with textiles being used by architects, we suggest transferring, adapting and developing the formgiving approach, meaning that textiles should be physically used as a potential rather than as a solution. In order to do this, we suggest using actual materials (in this case, textiles) in the model making. The materials known to an architect influence his design: “Materials are like words. The richer your design vocabulary, the more solutions you can see and express. There are no good or bad materials. Each one has its place, consequences and cost.” (Alesina & Lupton, 2010) (p.4). Our aim is to enrich that vocabulary through the two tools – one tool was tested in each of the two experiments.

The aim with the experiments was to answer the following research questions:

1. Can simple textile model making materials be used by architects to produce reasonable three dimensional sketches of architectural spaces?
2. Which characteristics of such textile model making materials and of their staging result in the best exploration of textiles’ possibilities?

To answer these questions, we present a review of existing studies and theory related to the material practice of architects and to the role of material libraries and material samples in this practice. We then describe two experiments, their specific aims, materials and methods, and results. We compare the two experiments and present our conclusions from an interview with a practitioner concerning the two experiments. Finally, we wrap up with a discussion of how the proposed tools for three dimensional sketching relate to existing ways of working with textiles in architecture.

### **Material Practice of Architects**

How do architects choose and apply materials in their work? And what kind of tools and techniques do they currently use? In the following two sections, existing answers to these questions are presented.

### *How Do Architects Choose and Apply Materials?*

Based on in depth interviews and focus-groups with architects, Lisa Wastiels proposes a model for the material considerations in an architect's material choice (Wastiels, 2010), shown in Figure 1. This mode consists of four overall categories of considerations (context, manufacturing, material aspects and experience) that are comparable to those identified by researchers within industrial design (Karana et al., 2008). The context influences the other three elements, which are interacting interdependently.

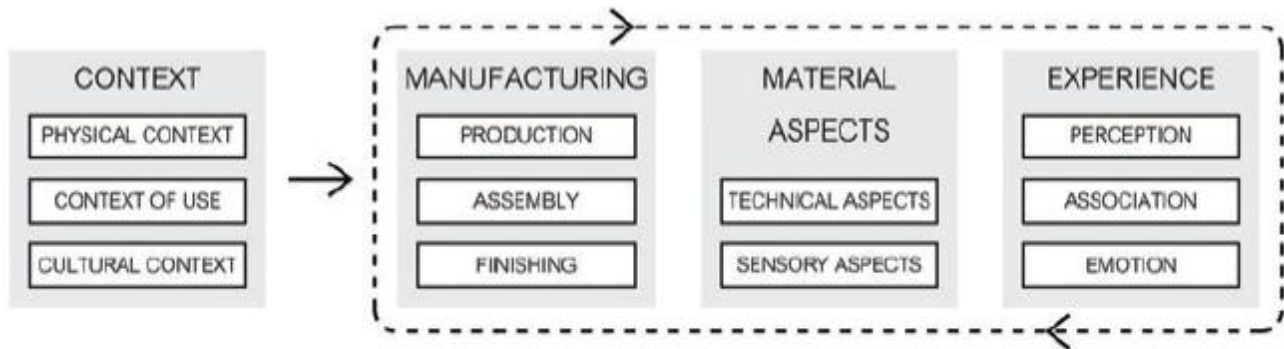


Figure 1 Model of material selection considerations, representing the relation between the different elements considered when choosing materials (Wastiels, 2010, p.60).

From a more practice-based perspective, A. Telier has studied architecture students and professional architects and describes an inspirational design environment as consisting of space, materials, devices, and people (Telier et al., 2011). Concerning the materials, their configurability and diversity is emphasized and it is pointed out that concepts are created by manipulating a variety of representations. Even though the variety of representations in the design process is emphasized, this description does not include the relation between the materials used in the design process and the materials used in the final design. Telier's description is more focused on how design ideas and concepts are developed, than on how specific materials are chosen and used in the development of such ideas and concepts.

### *Which Tools and Techniques Exist in the Material Practice of Architects?*

Over the last two decades, material libraries have evolved. These libraries can be both commercial and non-commercial, sometimes within educational institutions. They typically combine a physical collection of material samples with a corresponding virtual database of materials. They often focus on "new" materials, and try to stay up to date on recent developments on materials, in a way that individual designers or even studios are not able to. Designers and architects can visit these libraries physically and explore their material samples, and their interest in these show that they are generally aware of "new" materials. However, the step from being interested in a material sample to it being used in a design is large. Lisa Wastiels writes that architects use material samples to get an idea of the appearance and feel of materials (Wastiels, 2010), p. 78: "The use of material samples partially helps architects with the information on aesthetics and experiences, but they provide mostly a fragmented visual aid with little attention for the multimodal experience the material will contribute to." Wastiels' answer to the limitation of material samples is to create a correspondence between the experiential (non-measurable) properties of materials and measurable properties. Thomas Schröpfer's and Liat Margolis' answer is different: they describe how the material collection at the Harvard Graduate School of Design is used in a teaching module for first-year architecture students to explore materials and material operations at the

1:1 scale (Schroepfer & Margolis, 2006). They describe how this exploration in some cases became an essential source of inspiration for some of the students' projects later on.

Asterios Agkathidis and Gabi Schillig have also experimented with how the exploration of new materials can result in ideas for architectural spaces (Agkathidis & Schillig, 2010). They conducted experimental workshops with architecture students at the Technical University of Darmstadt in Germany and the Aristotle University of Thessaloniki in Greece, where students were asked to generate spaces by using simple model making materials and methods (Agkathidis & Schillig, 2010). No specifics regarding usage or scale were given. In Agkathidis' and Schillig's workshops, specific techniques were matched and combined with specific model making materials. An example of such a pairing is the techniques knotting, looping, and bending paired with the materials threads and metal wire. When describing these workshops, Agkathidis and Schillig focus on the results, but do not closer describe which combinations of techniques and model making materials were more or less fruitful.

Elisa Gutierrez and Olga Popovic Larsen have also conducted experimental workshops; their focus is on exploring the potential for expanding the applicability of small scale membranes (Gutierrez & Popovic Larsen, 2005). Based on this, they compare the use of sketching and model making in this process: "Building small physical models was then a rich natural process characterized by dialogue and feedback; closing loops as models progressed from rough to quite sophisticated designs. Physical models really proved a powerful springboard design tool that assisted participants to jump from understanding abstract physical concepts to solving practical issues and further into a more subjective stage of creativity exploration that provided some insight into a still little known world of possibilities. When comparing the effectiveness of sketches and small physical models, it was clear that the three-dimensional approach to design exploration through physical models was the most useful one." (pp. 230-231.) They explain the effectiveness of physical modelling by the fact that membranes are difficult to draw, even for experienced architecture students. It thus seems that, with textiles, the importance of physical model making is even bigger than for other materials, even though computer software does make it possible to do things that are difficult to attain through hand drawing.

Another research area where research is carried out on materials is Participatory Design (PD) research. In the latter, tangible working materials make it possible to visualize and materialize relevant issues and concrete proposals, and are therefore essential parts of the design process (Agger Eriksen, 2012). Heimdal & Rosenqvist have looked specifically at the use of textiles as tangible working materials in PD and co-design processes, and pointed to challenges related to the use of these (Heimdal & Rosenqvist, 2012). They write that textiles are unscalable and complex. Unscalable refers to the fact that textiles behave differently at small vs. large scale with respect to draping and form, but also with respect to how texture and pattern are perceived. Complex refers to how materials can be manipulated – whereas for example plasticine requires almost no tooling, handling textiles requires tools for cutting, joining, draping etc. According to Heimdal & Rosenqvist, textiles pose specific challenges, and need careful staging and tooling in order to be accessible for exploration in the context of architecture.

## **Methodology**

Our approach is to take the material samples further, by increasing their size and integrating them into model making. The two tested tools thus aim at making the visual aid provided by material samples less fragmented and are examples of materials, tooling and staging that make it possible to explore textiles.

What kind of design research are we then carrying out? Anna Vallgård and Cecilie Bendixen, who in their PhD projects have worked respectively with the computer as a material and with how textiles can be used in architecture for acoustic regulation, write: “There is a material side of design that we cannot address through the studies of use and social practice – the properties and potentials of materials, forms, and structures must be explored through another kind of studies. [...] How we can operationalize material objects by engaging them in situations that give us access to their properties and enable us to explore their potential.” (Vallgård & Bendixen, 2009), (p.1). Through the use of the two tools, we seek to facilitate the operationalization of textiles for the participating architecture and spatial design students. To do this, textiles’ possibilities and properties need to be communicated and made available for exploration. This can be done through different media: verbally (using words), numerically (using different kinds of technical data), figuratively (using pictures) and sensorially (using the physical textiles themselves). The focus of the two experiments is on the latter – bringing us back to the previously mentioned formgiving approach to materials in creative work.

Figure 2 shows an overview of the sequence of events of which the two experiments (Experiment 1 and 2) were part.

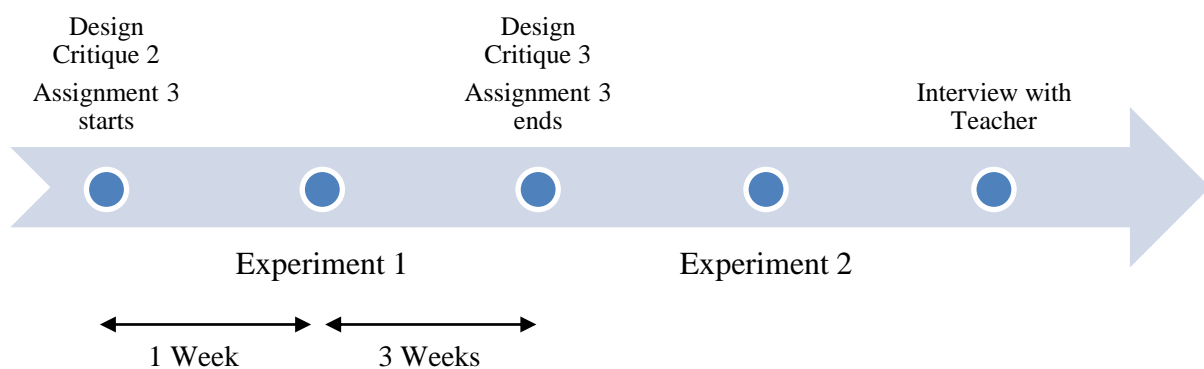


Figure 2 The chronological sequence of events of which Experiment 1 and 2 are part.

### Experiment 1: Free Textile Sketching

#### *Specific Goal*

In addition to providing answers to the two research questions formulated in the introduction, the specific goal with the experiment was to test whether simple textile model making materials staged in a open-ended free way (no limitations) can be used by architecture students to produce reasonable three dimensional sketches of and to develop ideas for a textile building skin.

#### *Context*

This experiment took place as a workshop in the context of a teaching module called *Architectural Design: Performance*, taken by architecture students at UTS at the end of their second year. The workshop lasted 1.5 hours and constituted the first half of a three hour tutorial, which was part of the teaching module.

Before Experiment 1, the Design Critique for the teaching module’s second assignment (referred to as Design Critique 2 in Figure 2 and in the following) was held. This assignment asked students to re-design an existing interior space within the UTS Tower Building. Design Critique 2 gave insight into





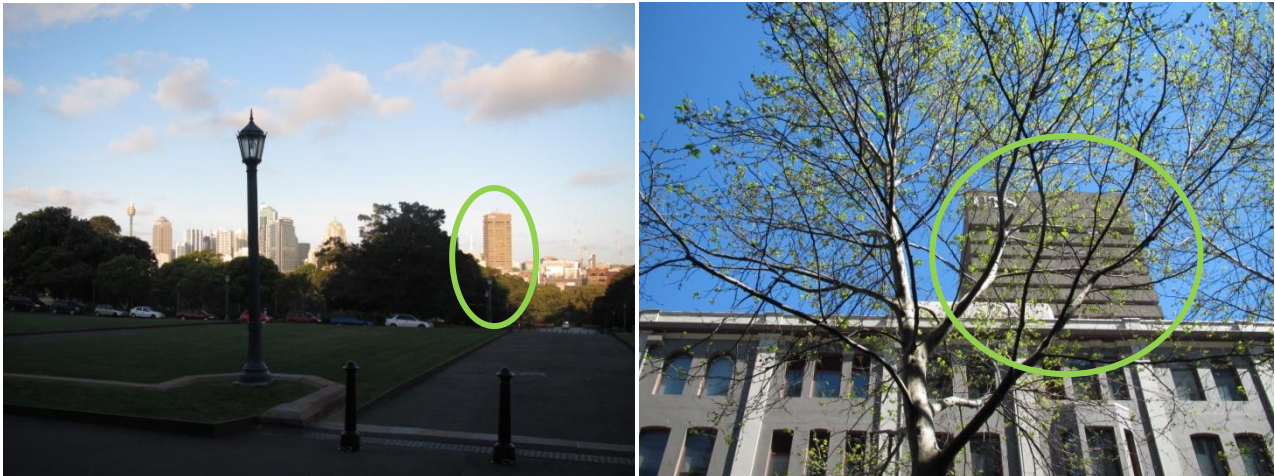


Figure 4 The UTS tower building seen from far away and from close up. Left: the building is clearly visible in the Sydney skyline. Right: The building consists of horizontal concrete slabs separated by windows.

The UTS tower was constructed using a post-tensioned concrete technology. Therefore, the students were allowed to remove some concrete from the exterior wall up stands if they wanted to, but all structural columns had to remain in their existing positions.

The redesign of the building envelope for the UTS tower was the third and last assessment task in the module. The students had four weeks to complete the task. Experiment 1 was held when they were one week into these four weeks, as shown in Figure 2. They were thus in the early phases of their design process. All groups except one had some photographs/renderings of existing projects and/or early sketches that they referred to when explaining the current status of their project. These were used to communicate their ideas internally in each of the groups, with their teacher and students in other groups.

#### *Materials and Method*

The students were introduced to two specific textiles (silicone coated woven glass fibre fabric and coated polyester mesh) for building skins alongside examples of their applications. They were then introduced to the workshop task (see left, Figure 5), which was to make a model of a textile skin for the UTS tower building using the following materials: a cardboard 'corner' (the two sides each measuring approx. 50 x 70 cm), a piece of woven black polyester fabric (approx. 60 x 90 cm), 2 pairs of scissors (to cut fabric), 1 cutter (to cut cardboard), metal wire (to create structure underneath fabric) and a staple gun (1 for two groups, to attach the textile and possibly the wire to the cardboard) (see right, Figure 5). The polyester fabric had an open plain weave structure, imitating the coated polyester mesh introduced to the students.



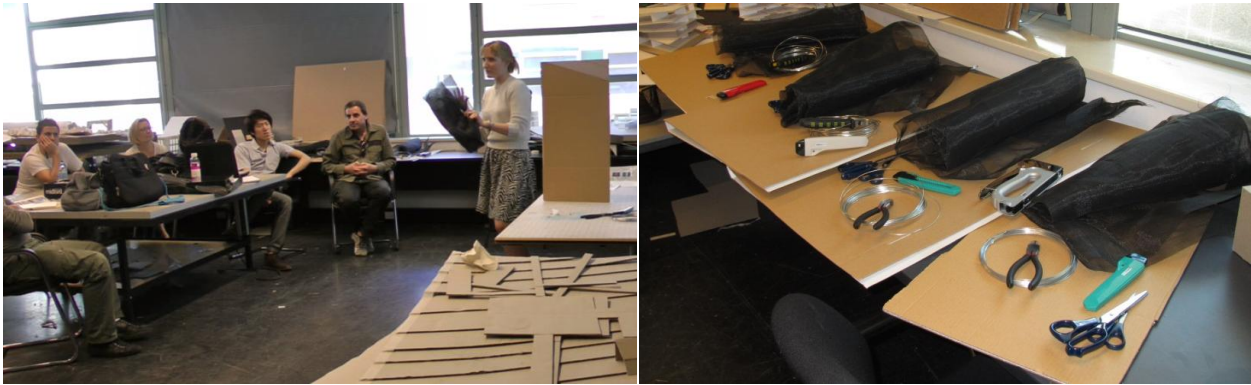


Figure 5 Left: Introduction to the workshop task. Right: Materials prepared for each of the four groups.

The workshop itself consisted of the following four phases:

1. Presentation by each group of the status of their project (15 minutes)
2. Presentation by me of specific textiles and examples of how these can be used as building skins (15 minutes)
3. Hands-on workshop task (45 minutes)
4. Show & tell (15 minutes)

Following up on the workshop, the third and last Design Critique of the module (Design Critique 3) made it possible to see whether the workshop had in some way influenced the students in their material choice.

The same group of fourteen students and their teacher participated in the two Design Critiques as well as in Experiment 1. The students were divided into four groups in total: two groups of four students and two groups of three. The students worked in these groups for their assignment. During the workshop, their teacher (Nicole Gardner) gave feedback on the proposals developed by the students.

The workshop was filmed using two cameras that each filmed two groups. The video material was used for the analysis by looking at material and group dynamics. Material dynamics is the way in which the students approached and used the provided materials. Group dynamics is how each of the four groups divided and organized work among its participants.

## *Results*

### Material Dynamics

Three groups started experimenting with the materials and making something with them immediately, while one group spent time planning and discussing what they were going to make before actually using the materials.

Another issue at the beginning of the process was which of the materials to start with: the fabric or the wire? The cardboard was used as support for these two materials, either both of them or only one of them, depending on what the students used.

In group 2, the participants worked individually, one student working with the wire and another with the textile (see Figure 6). As they experimented separately, the two materials were used at the same time,

but not together. The students in this group did not talk much with each other during their individual experimentations. They made a first model consisting of each their piece of wire and/or wire attached to the cardboard, but did not seem satisfied. Consequently they took everything down from the cardboard support and made something else, also individually working on each their part. However, the short time frame and materials given to the students did not easily allow for such iterations.



Figure 6 Group 2: Which material to start with: the fabric or the wire?

Group 4 spent time developing their idea before engaging with the materials. The wire was the material that they used first (see Figure 7 ), to make an underlying structure that would then be covered with the textile. Two of the members in group 4 took photographs with their mobile phones of their model as it was finished, as a way of documenting the result.



Figure 7 Group 4: Discussing the shape and then making the underlying structure.

In group 1, the wire was not used at all. Instead, the group members focused all their attention on the piece of textile, which was cut in triangular pieces that in a way constituted the modules of their building skin (see Figure 8).



Figure 8 Group 1: Left: Whereas one group member is working on choosing a scale (1:50, 1:100, 1:200), another has started cutting the textile in triangles and seeing what can be obtained by layering the pieces. Centre and Right: The triangular pieces are attached to the cardboard corner.

None of the groups used the cutter to make, for instance, openings in the cardboard.

### Group Dynamics

The participants in group 2 worked individually (see Figure 9) and their work was not coordinated. Each of them was working with different materials, on each their part of the cardboard “wall” and on different ideas. There was not very much verbal dialogue between the participants, and from where they were standing, the participants were not all seeing what the other group members were working on.



Figure 9 Group 2 members working on different ideas without coordinating.

In group 1, tasks were clearly divided, almost like in a production process. While one student was cutting the textiles into triangles, another was attaching them to the cardboard (see Figure 10, left), and a third one was measuring the cardboard to decide on a scale. A kind of hierarchy was also observed in this group, as one of the members of the group cutting out the pieces of textile, after making a textile element with the textile triangles, seemed to reject his own textile element (see Figure 10, right).





Figure 10 Left: One group member is working on scale, while the two others are cutting the textile. Right: One of the group members has made a textile element. He shows it to the others, but puts it away. It is not used.

The last two groups worked together in a more collaborative way, meaning that the group members were all engaged on the same task and helped each other making the model (see Figure 11). This was reflected in the results, as the groups working together provided holistic and less fragmented solutions, and used the entire piece of cloth. The other groups cut it into smaller pieces. One group did this because they did not seem to agree. In another group they did it to divide work and to create a design based on modules of the same size.



Figure 11 Left: All three members of group 4 are attaching the textile to the shape they have created by attaching the wire to the cardboard. Right: All three members of group 3 are stretching and attaching the textile to a shape they have created by attaching the wire to the cardboard.

The groups did not talk very much during the workshop, but seemed to communicate a lot through gestures while making the model. One way of understanding this behaviour is that the materials themselves served communication purposes. By making something and showing it to the other participants, ideas can in fact be shared without talking. Expressing ideas with words might even be difficult.

### Textile Models

The models produced by the four groups were very different, as shown in Figure 12.

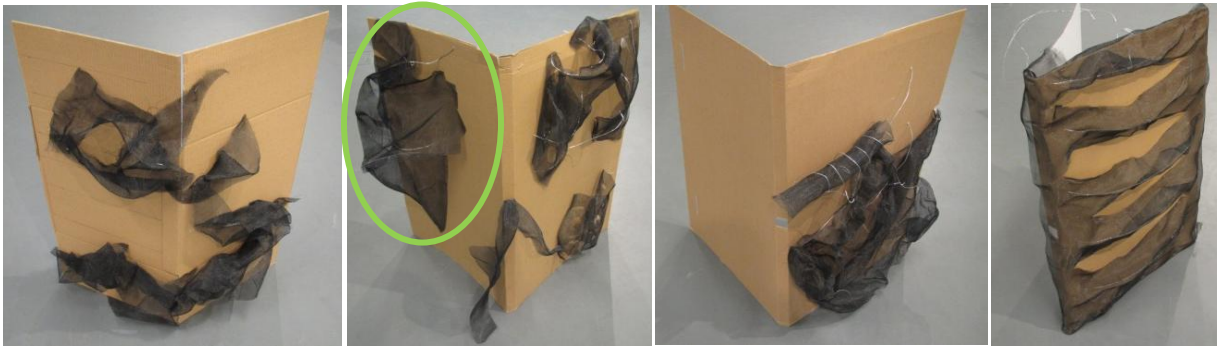


Figure 12 From left to right: Results for group 1, 2, 3, and 4 respectively.

The solutions from group 1 and 2 are similar, but they differ in several aspects. While group 1 used only the textile to make the building envelope, group 2 used the textile and the wire. Group 1's solution is based on modules, i.e. triangular pieces of fabric, that have been attached to the cardboard to create one continuous organic shape, while group 2's proposal is made of pieces of textiles of different shapes and sizes, attached to an underlying metal structure. Some of the volumes created are geometrical, such as the pyramidal shape created on the left side of the model (in the green circle in Figure 12).

Below we further describe and explain the model made by each of the groups and link the model to the ideas they had at the beginning of the workshop.

Group 1 explained at the beginning of the workshop that they wanted to link together different parts of the UTS Tower. Their final model, far left in Figure 12, shows a way of doing this. By constructing a building envelope that creates an opening in the upper parts of the buildings, a link to the bottom of the building is made and the building envelope becomes thicker to create shades in the foyer area (Figure 13).

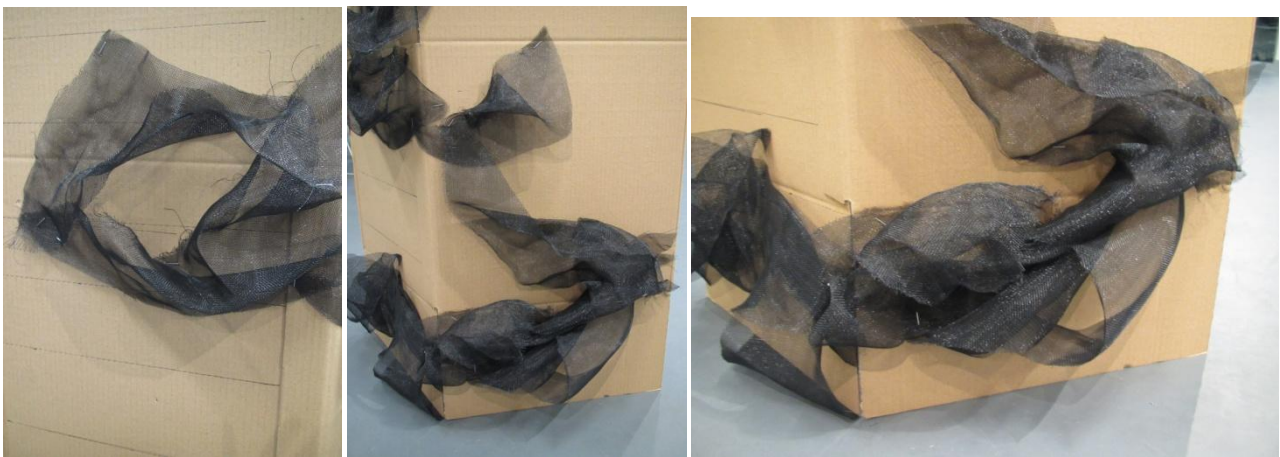


Figure 13 The three different parts of group 1's solution. Left: Opening in the upper parts of the building. Centre: Connection of opening to the lower part of the building. Right: Many layers of textiles wrapped around at the lower part of the building.

Group 2 explained at the beginning of the workshop that their idea was to change the shape of the UTS tower building by applying a building skin to it. They had several pictures and an illustration of ways of doing this. When explaining their result, they referred to these pictures (see Figure 14, left and right).



They had used the materials to create new (three-dimensional) representations of the concepts represented on these pictures. As the different members of the group did not agree on which of these sources they wanted to use, each seemed to have used a different one, and during the presentation they thus referred to two different illustrations (see Figure 14, left and right).



Figure 14 Group 2 is showing illustrations to explain the intention with the model.

Group 3 also brought inspirational pictures that were used during the workshop (see Figure 15). The group was trying to create a model corresponding to a picture, but had a hard time using the provided materials to do this. Their way of working was thus quite similar to group 2, except that the group members worked together in a more collaborative way.



Figure 15 Group 3 is trying to create what is on the inspirational image.

Group 4 developed their concept during the workshop (see Figure 16), and the final result had no clear reference to the building they were looking at for inspiration at the beginning of the workshop. This was the only group where the final result did not seem to be linked to any idea or reference they had brought to the workshop.





Figure 16 Group 4 cutting the textile after it has been attached to the underlying metal structure.

Given the openness offered by the materials and the task given to the students, they had to choose a strategy for how to explore the materials. By “strategy” we mean the way they worked with the materials, based on their actual actions rather than mental plans, as strategies are usually thought of. They had to decide whether they wanted to experiment immediately or spend time thinking through what they wanted to do. They also had to decide which material to start with and choose whether to use the textile as a whole or cut it into pieces. An open task with a high degree of freedom is more challenging than a closed one, due to the series of choices to be made and agreed upon by the members of each group. The groups made quite different choices, resulting in different models. The different choices each group made can be grouped into strategies for how they approached the materials and the workshop task. Summing up, the differences when it comes to the material dynamics can be described using the following three strategies:

- Strategy 1: Use the materials to **materialize** a(n existing) concept: (Group 1) The materials were used to materialize an abstract concept.
- Strategy 2: Use the materials to **illustrate** a(n existing) concept: (Group 2 and 3) The materials were used to create a model that illustrates in another format a concept that already exists in a two-dimensional visual form (picture or sketch).
- Strategy 3: Use the materials to **develop** a (new) concept: (Group 4): The materials were used to develop a (new) concept, using the materials’ properties as point of departure.

The goal of the proposed tool was to help the students explore the possibilities of textiles for daylight regulation. A strategy where the materials are used to develop a concept thus might seem the most desirable strategy. However, the open format in this first experiment, made it difficult to focus on this alone. In Experiment 2, the model making materials were staged in a more constrained way, in order to at a greater extent facilitate the development strategy.

## Experiment 2: Constrained Textile Sketching

### *Specific Goal*

In addition to providing answers to the two research questions formulated in the introduction, the specific goal with the experiment was to test whether simple textile model making materials staged in a constrained way (with limitations) can be used by spatial design students to produce reasonable three dimensional sketches of and to develop ideas for two interior spaces using textiles, with focus on light.

### *Context*

Experiment 2 was not part of any teaching module, and the students had been recruited by their coordinator through an “appetizer” sent by e-mail. Eleven spatial design students from UTS participated. Four of these were at the end of their third year of study, while seven were at the end of their fourth year study.

### *Materials and Method*

The students were given a cardboard “room” consisting of two walls, a ceiling and a floor, of dimensions approximately 35 x 35 x 35 cm, of which the ceiling and floor were covered with white foam board (Figure 17, left), a translucent textile cut into three square pieces (Figure 17, right), a scenario (e.g. a short description of a person working in an office space) and a limitation (the textile must be attached to the ceiling). The students created spatial configurations with the textiles, and took photographs of these configurations, holding the room up to a light source.



Figure 17 Left: Open ended box with foam board in ceiling and on the floor. Right: Pins and three pieces of fabric no. 1 (polyester chiffon).

After some time, the limitations were loosened and in addition to attaching the textile to the ceiling, the students were allowed to cut the textile. Finally, the first textile, a woven grey polyester chiffon (non-elastic, 38g/m<sup>2</sup>) was replaced by a meshed lycra chiffon (elastic, 65g/m<sup>2</sup>) in a darker shade of grey. At this point, the scenario was also changed to an exhibition display in the lobby.

The choice of textiles was based on the three principles of textiles and daylight defined by Boutrup and Riisberg – the importance of density, number of layers and distance between layers of textile (Boutrup & Riisberg, 2010). These principles were introduced at the beginning of the workshop.

## Results

Whereas in Experiment 1, the strategies used by the groups were quite different from one another, in Experiment 2, the four groups approached the materials in similar ways. This was not surprising, as they were given clear instructions on what to do. However, what was interesting was the kind of exploration of the textiles this facilitated. In the following, we describe the steps the students used to explore the textiles to make the different configurations.

First, time was spent exploring the pieces of fabric by touching, looking through and stretching them, without putting them inside the box (see Figure 18). As the groups consisted of two to four persons, each person would typically take one of the three pieces of fabric.



Figure 18 Getting to know the new textile. Left: Group 4. Right: Group 3.

Gradually the pieces of fabric were held up in the box, without attaching them (see Figure 19).



Figure 19 Placing one of the pieces of fabric inside the box without attaching it. Left: Group 4. Right: Group 3.

Finally, the pieces of fabric were attached, held up to a light source, and photographed (see Figure 20).



Figure 20 Left: Group 4 holding a configuration up to a light source. Centre and Right: Group 4 taking pictures with a phone, using the flashlight from another phone as light source.

As the box/room could be accessed from both sides, two or more students could work on it at the same time (see Figure 21), which made it easy for them to work on the task in a collaborative way.



Figure 21 Accessing the room from each their side.

Most of the groups started experimenting with the textiles quickly, but one group (group 2) spent a long time planning and discussing before engaging with the materials. One of the group members explained, as the second textile was handed out: “It took us a little while to get into our groove. Now we can do it.” Even though the other groups had engaged more quickly with the materials than group 2, it seemed that when they were given their second textile, it took less time before they started trying it out in the space provided by the cardboard room. They seemed to be “warmed up,” as though having tried the tool once made them more confident.

The following steps were followed by the students:

1. Getting to know the textile (“touch and feel”)
2. Testing the textile in the box without attaching
3. Attaching
4. Seeing
5. Changing
6. Taking pictures

Relating these steps to the way materials are used in a material library, one can say that the “touch & feel” is just the first of several steps in the exploration of a material. It is a necessary step, but the exploration certainly shouldn’t stop there – steps 2-6 are examples of how material samples can be brought further, by using them in model making, which we refer to as three dimensional sketching.



### Textile Models

As each group took pictures of the configurations they made, these were shared by e-mail in order to show them to all participants at the end of the workshop. At the final Show & Tell, the students explained what they had made for each scenario. In the following, we provide some examples of this.

Group 1 had chosen to hang the textiles horizontally in scenario 1, creating a kind of sky (see Figure 22). They seemed to focus more on the poetics of this sky than on its effect on daylight.



Figure 22 A sky in the office, made by group 1.

Group 2 used the textiles vertically, and took pictures simulating the movement of the sun through morning, noon and night (see Figure 23), showing how the textile created different shadows on the wall (indicated by an arrow on Figure 23), depending on what time of day it was. This was more in line with the scenario provided, than the sky proposed by group 1.



Figure 23 Shadows in the office space changing with the movement of the sun, made by group 2.

Common for all the groups was that they took many pictures, although they were asked to take only three for each scenario. Even when they had made quite simple configurations, which were not their final ones, they took pictures (see Figure 24) maybe as a way of documenting the process. This shows that the tool functioned as a sketching tool – more important than the final results, the process itself and its documentation was a sketching process, as defined by Pirjo Birgenstam (Birgerstam, 2000).



Figure 24 The first pictures taken by group 3. Taken before the illustration of the scenario had been made, these pictures were trials.

As group 1, group 3 chose to make a configuration with the textile hanging horizontally. The students in this group were inspired by some experiments they had made with tracing paper, and tried to cut the textile the same way they had cut the tracing paper, as the second degree of freedom was introduced (see Figure 25). They were interested in the shades this created in the office space. They were hence trying to transfer an experience with one material to another material.



Figure 25 Configuration made by group 3, after the second degree of freedom had been introduced.

Group 4 chose to use the textile vertically, and introduced their own degree of freedom, which was to attach the pieces of fabric to the walls (see Figure 26).



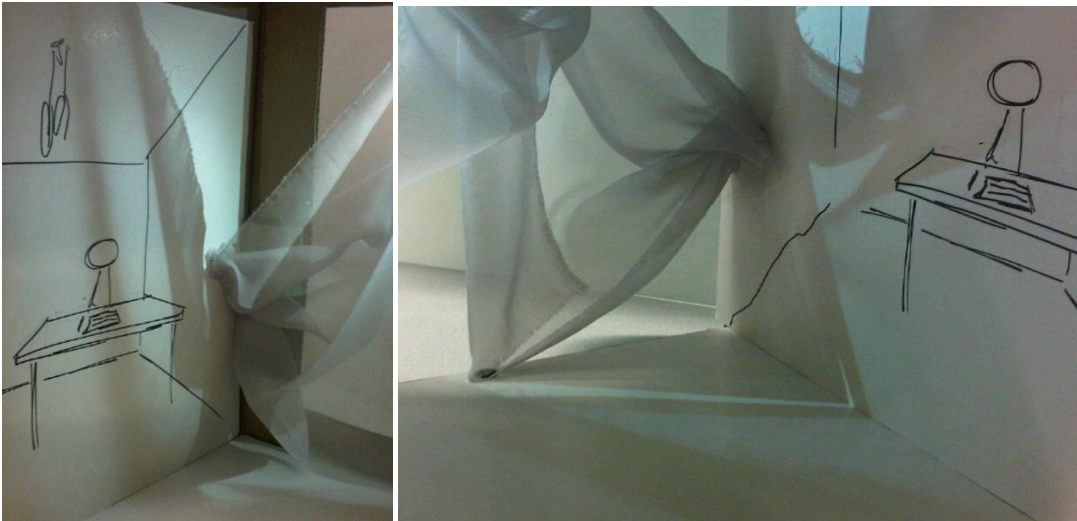


Figure 26 Pictures taken by group 4 for scenario 1.

Figure 27 shows some of the configurations made for the lobby scenario by group 3 and 4.

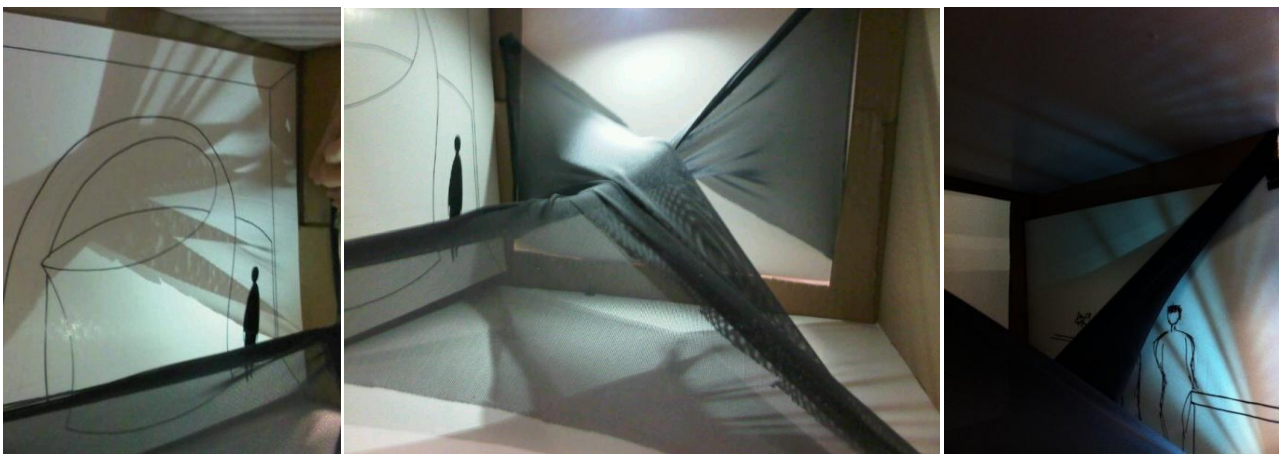


Figure 27 Left and Centre: Pictures taken by group 4 for scenario 2. Right: Picture taken by group 3 for scenario 2.

### Comparison of Experiment 1 and Experiment 2

Having now described both Experiment 1 and 2 in details, we would now like to briefly compare the two. Table 1 summarizes a number of details about the two experiments.

Table 1 Comparison of the two experiments

Aspect	Experiment 1	Experiment 2
<b>Participants</b>	14 architecture students (4 groups)	11 spatial design students (4 groups)
<b>Duration</b>	1,5 hours	2 hours
<b>Object of design</b>	Exterior building skin	Textiles for interior spaces
<b>Focus</b>	Daylight	Daylight
<b>Introduction</b>	Presentation of two specific textiles for building skins, and examples of uses of these	Presentation of three principles concerning regulation of daylight using textiles
<b>Materials</b>	Cardboard, metal wire, textile and tooling	Cardboard "room," pieces of textiles and tooling
<b>Instructions</b>	Open: Make a model of a building skin	Constraints and controlled progression

Contrasting the openness of Experiment 1, the limited degrees of freedom in Experiment 2 resulted in more solutions, producing good three-dimensional models. The latter showed a deeper exploration of the possibilities of textiles for daylight regulation. Whereas Experiment 1 resulted in somewhat two-dimensional models, Experiment 2 resulted in spatial solutions, because of the fewer degrees of freedom.

Looking closer at the specific textiles that were used in the two experiments, it can be said that the two fabrics (chiffon and mesh) used in Experiment 2 differed from the woven polyester mesh in Experiment 1 by not staying in the shape they were given unless they were fastened. The mesh in Experiment 1 was in fact stiffer than these two fabrics, and when folded or shaped in some way, it would stay in that shape. This can be seen as an advantage, but together with the metal wire and stapling, the materials in Experiment 1 were more challenging to work with than those in Experiment 2, who were more easy and pleasing to work with. In addition to the staging, as mentioned in the previous paragraph, the resistance of the materials is also important when the goal is to promote the exploration of the materials.

### Interpretation and Extendibility of Results

The participants in Experiment 1 and 2 were all students. In order to extend the results to practice, and to deepen their interpretation, Nicole Gardner, a registered architect in New South Wales (Australia) with ten years of professional experience, was interviewed. She participated in Workshop 1, and she was the teacher responsible for all the students participating in this experiment throughout the whole teaching module. During the interview, she was presented to Experiment 2, its materials and methods, and shown pictures of the textile models produced by the students.

Describing what the participating students gained from Experiment 1, the interviewed architect said: "It definitely opens their eyes to the possibilities of textiles." She also compared the tool to traditional sketching (with paper and pencil): "The sketching particularly for textiles is not as useful because it's really, it could be really quite difficult to understand the translucencies and opacities through a sketch." The tool thus made the students realize textiles was a material they could use for the building skin, and the model making proved to be a suitable way of exploring this material.

The interviewed architect agreed with the interpretation that the students used three different strategies (using the materials to *materialize*, *illustrate* or *develop* a concept), and added: “It is about letting the material push you into an idea as opposed to having an idea that you realise in a material.”, thus arguing for the third strategy (use the material to *develop* a concept).

Discussing what could have been done differently in Experiment 1, she proposed: “One of the things that could have been done was to set out an agenda for exploring different types of conditions such as opacities and translucencies. ‘Do this, then try this’, where I think they just did whatever and they didn’t have a strategy for doing it and I think that if they’d taken that and done a couple of different things on the facade it might have given them a better understanding of the material properties.” She thus highlighted the importance of limitations and clear progression. Consequently, she found the staging in Experiment 2 very appropriate, and explained it would have been very useful for her students to explore textiles in that way, in addition to the way tested in Experiment 1.

The interviewed architect, argued that the tools would also be suitable in a professional practice, where they could be used early in the design process, as a way of literally sketching with textiles to expand one’s material repertoire. As a concluding remark, it can be said that although the tools have been tested on students, they are also likely to be useful to professionals.

## Discussion

One can ask how representative the two experiments are. The participants had backgrounds within architecture and spatial design. With this background, the two tools functioned in a certain way, and the participants’ background probably contributed to this. Students are used as a means to reach the overall aim, which is related to architects. A. Telier discusses the difference between students and professionals: “There are some obvious differences between how professional designers work and how students of design work that are mostly to do with the fact that large part of professional design work consists in detailing a design so that it can be produced, a process that involves a myriad of technical problems and requires dense cooperation with specialists of all sorts, under tight budget and time constraints. But when we look at the creative conceptual aspect of design work, we find striking similarities.” (Telier et al., 2011) pp. 43-44. The fact that there are striking similarities between students and professionals when it comes to the creative conceptual aspect of design work makes it possible to say something about the use of the two tools by professionals, although they were tested on students.

Yaneva, p. 867 describes “*how architects involve themselves in a comprehensive dialogue with materials and shapes*”, and emphasizes the importance of a constant back and forth movement between small scale and big scale during the making of a building (Yaneva, 2005). The two tools are at the small scale, and our focus is on the interaction between the materials and the students. As a next step, it could be interesting to see what happened to the developed ideas if small scale model making was followed by model or prototype making at a bigger scale.

The two presented tools are examples of how to work with textiles in an architectural design process. A similar way of doing this is exemplified by the British architect Will Alsop. In an interview, he explains how he uses sketch models with tights and pencils or different kinds of fabrics to develop his ideas (Garcia & Alsop, 2006). He says: “the idea of playing around with bits of fabric and a model is still very productive. It is nonsense that if you are not adept at the computer you can’t produce innovative forms

or architecture.” (Garcia & Alsop, 2006) (p.39). This brings us to the research of Mette Ramsgaard Thomsen who is exploring the link between textiles and computation through 1:1 research by design, meaning that she links software (such as Rhino) to physical production, e.g. through the knitting of structures produced on the computer screen (Ramsgaard Thomsen, 2008). Our research is based on the assumption that by making physical models with textiles, motivation for using textiles is raised, and the awareness of their potential for architecture increased. We do not deny the current importance of software in the architectural design process, but simply highlight the importance of physical interaction.

## Conclusion

Two experiments were conducted with tools for three dimensional sketching with textiles. Based on these experiments, we can answer the first research questions (*Can simple textile model making materials be used by architects to produce reasonable three dimensional sketches of architectural spaces?*), by saying that: Yes, simple textile model making materials can be used by architects to produce reasonable three dimensional sketches of architectural spaces. Even with no prior experience with textiles, the tools could be used to make three dimensional sketches with textiles. Answering the second research question (*Which characteristics of such textile model making materials and of their staging result in the best exploration of textiles' possibilities?*), we can say that characteristics of such textile model making materials that are important is a limited amount of materials and tools and ease of handling. We can also say that a staging with limitations and clear progression results in the best exploration of textiles' possibilities.

## Acknowledgements

We would like to thank the faculty at UTS who helped in the organization of the two workshops and recruiting students: Lecturer Nicole Gardner, Senior Lecturer Samantha Spurr, and Lecturer Juan Cabello. A special thanks to Nicole Gardner for also taking time to share her insights in the interview.

We would also like to thank the students participating in the two workshops: Workshop 1: Eric Ye, Henry Goodwin, Nick Wenham and Ashwini Ching (group 1), Laszlo Kotvan, Robert Scarfone, Miki Neckoski and Sudden Matsa (group 2), Jaiwei He, Tina Ngyuen and Kim Vo (group 3), Robert Porter, Karina Zadvina and Jie Wei Li (group 4), Workshop 2: Alena Minaeva and Carla Matias (group 1), Audrey Ano, Jessica Suhandynata, Clare Pettitt and Holly Jenkins (group 2), Quincy Ye and Dennis Choi (group 3), Stephanie Shehata, Teresa Meoli, and Jenny Yu (group 4).

Unless otherwise stated, Elisabeth Heimdal is the author of figures and photographs. When a group number is mentioned in the figure caption, all group members are considered authors of the photograph.

This research was carried out as part of my PhD project, financed by the Technical University of Denmark. My research stay at UTS was possible thanks to an EliteForsk travel scholarship granted by the Danish Ministry of Science & Innovation.

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